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RADON MASS EXHALATION RATES FROM SOIL SAMPLES OF OIL EXPLORATION AREAS IN MIZORAM

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Abstract

Investigation of radon mass exhalation rates of soil samples collected from Maubuang, Keifang, Phulmawi, Thenzawl, Zanlawn and Meidum oil exploration area of Mizoram, India is carried out. Measurements were carried out using the scintillation-based Smart RnDuo radon detector. The measured radon mass exhalation rates in Aizawl district ranged from 7.27 to 23.49 mBq/kg/h with an average value of 12.43 mBq/kg/h. In Kolasib district it ranged from 7.04 to 17.88 mBq/kg/h with an average value of 12.13 mBq/kg/h. And in Serchhip district it ranged from 9.42 to 19.82 mBq/kg/hwith an average value of 13.04 mBq/kg/h. The combined oil exploration areas showed values ranging from 7.04 to 23.49 mBq/kg/h with an average value of 12.40 mBq/kg/h. Grain size distribution analysis indicated that radon exhalation tends to be higher in samples with more uniform grain size distribution. The results provide baseline information on environmental radioactivity and may be useful for future radiation safety studies in Mizoram.

Keywords: Radon mass exhalation rate, Smart RnDuo, Environmental radioactivity.

1. INTRODUCTION

Primordial radionuclides such as ^{238}U and ^{232}Th are found in traces almost in every soil, rocks and water on earth. They usually have a very long half-life and continuously decay into another radioactive element, hence forming a decay chain. Radon, a decay product of ^{238}U, is a highly radioactive, colourless, chemically inert gas and is one of the main sources of radiation exposure to human beings (UNSCEAR, 2000). Of the total radiation received by humans, the contribution of radon and its decay products is 51% through inhalation and 0.21% through ingestion (Kumar et al, 2017; Gusain et al, 2009). Due to its short half-life, radon continuously disintegrates into its progeny, thereby releasing alpha particles. The three main progenies of radon, namely, polonium, lead and bismuth have extremely short half-life and this makes radon extremely hazardous (Majumdar, 2000, Ahmad et al, 2014).

Radon is being continuously formed in the soil and released in air. Radon formed in the soil enters into the pore spaces of soil grains by a process called emanation and then escapes into the environment by a process known as exhalation (Elzain, 2015, Al-Saadi et al, 2015). Exhalation mainly depends on the type of soil, its grain size distribution, porosity and the water content of the soil.

Radon and its isotopes have been identified as the second leading cause of lung cancer after tobacco smoking (Hassan et al, 2011, Mujahid et al, 2010). Hence, estimation of radon mass exhalation rate is important to give a useful reference against radiation safety measures and to create a baseline for further studies.

ThE present work aims to measure the radon mass exhalation rate and also to determine grain size distribution for classification of soil samples collected from all the oil exploration areas within Aizawl district, Kolasib district and Serchhip district of Mizoram. Mizoram is one state in the north-eastern part of India. The main instruments for the study is by utilizing a scintillation based radon detector Smart RnDuo.

2. STUDY AREA

Mizoram is located in the North Eastern part of India. There are altogether six major oil exploration areas in Mizoram such as Phulmawi, Maubuang and Keifang area located at Aizawl district; Meidum and Zanlawn area located at Kolasib district; and Thenzawl area located at Serchhip district respectively.

Phulmawi area stretches from $23^0$35’29.9”N to $23^0$35’33.1”N and between 92’51’23.0”E to 92’51’25.0”E with an elevation range of 2900 ft and 2956 ft from sea level. That of Maubuang area stretches from $23^0$29’42.7”N to 23^0 29’ 47.3”N and between $92^0$42’3.6”E to 92^0 42’5.8”E with an elevation range of 2870 ft and 2885 ft from sea level. Keifang area stretches from $23^0$39’12.5”N to $23^0$39’14.2”N and between $92^0$57’0.9”E to $92^0$57’1.7”E with an elevation range of 2915ft to 2927ft from sea level. Thenzawl area stretches from $23^0$18’08.3”N to $23^0$18’12.4”N and between 92’42’5.8”E to 92’47’11.9”E with an elevation range of 2454 ft and 2483 ft from sea level. That of Meidum area stretches from $24^0$10’11.8”N to $24^0$10’12.9”N and between $92^0$35’55.4”E to $92^0$35’58.8”E with an elevation range of 291ft to 331ft from sea level. And that of Zanlawn area stretches from $23^0$59’01.0”N to 23^0 59’ 02.6”N and between $92^0$42’47.8”E to 92^0 42’50.8”E with an elevation range of 2110 ft and 2900 ft from sea level.

The Fig.1 shows the location maps of all the oil exploration areas in Mizoram.

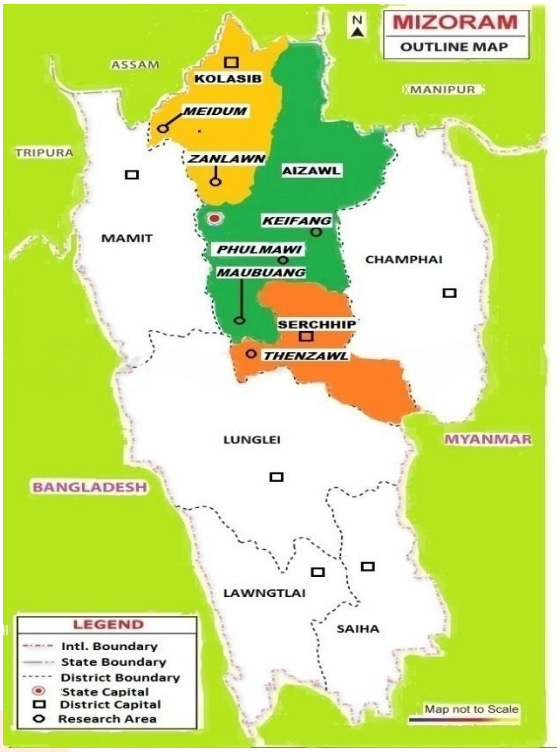
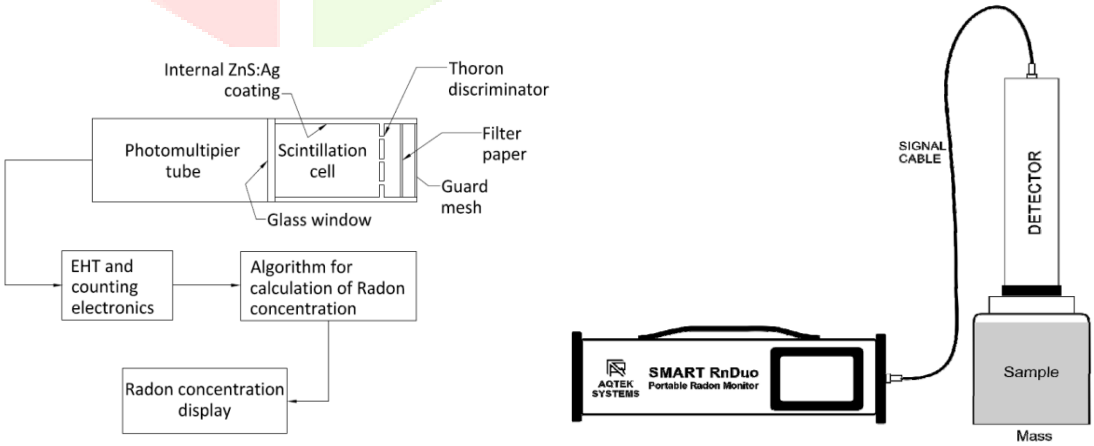


Fig.1. Geographical Map of Mizoram showing different Oil Exploration areas

3. MATERIALS AND METHODS

3.1 Measurement of Radon Mass Exhalation rate: The measurement of radon mass exhalation rate in collected soil samples was carried out by using a scintillation based radon monitor Smart RnDuo. RnDuo is an advanced portable continuous radon /thoron monitor, whose detection principle is based on detection of alpha emitted from radon and its decay products formed inside a scintillation cell volume, and has multiple applications in radon and thoron studies (Amanjeet et al, 2018). The instrument consists of a progeny filter and a thoron discriminator which eliminates radon/thoron progenies and thoron from entering the scintillation chamber. The alpha scintillations from radon and its decay products formed inside the cell are continuously counted by the PMT and the associated counting electronics. The instrument has an in-built algorithm to continuously measure radon concentration. The measured radon concentration is then processed by a microprocessor unit as per the developed algorithm to display the concentration of radon (Fig. 2).



(i) (ii)

Figure 2: (i) Schematics of radon measurement process in RnDuo. (ii) Measurement of radon mass exhalation from soil.

For measuring radon mass exhalation rate, the sample was first weighed and its volume taken, and then put inside the radon mass exhalation chamber. The detector is then mounted on top of the exhalation chamber (Fig. 2), and radon build up data were recorded every 60 minutes for a period of about 10-24 hours. The readings for 10 consecutive huurs is taken out of the 24 hrs. This is done to ensure that the readings are accurate. Least square fitting of the data obtained was carried out using the equation (Lekshmi et al, 2018):

$$C(t) = \left(\frac{J_m M}{V} \right) t + C_o$$

Where C (t) is ^{222}Rn concentration (Bq m^{-3}) at time t, C_o is the ^{222}Rn concentration (Bq m^{-3}) present in the chamber volume at t = 0, M is the total mass of the dry sample (Kg).

V is the effective volume (volume of detector + porous volume of sample + residual air volume of mass exhalation chamber) (m^3).

The porous volume (V_P) can be estimated using the following equation

$$V_P = V_s - \left(\frac{M}{\rho_g} \right)$$

Where V_s is the sample volume in the mass exhalation chamber, ρ_g is the specific gravity of the sample and t is the measurement time (h).

On least square fitting of the data to the above equation, one may obtain J_M from the fitted parameters with the information of the mass M of the sample.

3.2 Soil Classification and grain size distribution: Sample soil classification was carried out by adapting the United States Department of Agriculture (USDA) textural soil classification system. It consists of three main primary classifications, namely, sand, silt and clay. These three classifications are further divided into 12 classes. A triangular plot, called the USDA triangle was employed for this purpose (García-Gaines et al, 2015).

Sample soils were first dried and then sieved using a mechanical sieve shaker for a period of 20-30 minutes. Five different sieves of sieve mesh number, namely, 60 (grain size 0.25 mm which corresponds to medium sand), 120 (grain size 0.125 mm which corresponds to fine sand), 230 (grain size 0.0625 mm which corresponds to very fine sand), 325 (grain size 0.044 mm which corresponds to silt/mud) and >325 (grain size smaller than 0.044 mm which corresponds to clay) was used to identify the grain size distribution. Percentage of the grain size distribution obtained was then plotted using the USDA triangular plot.

4. RESULTS AND DISCUSSION

Table 1: Determination of grain size distribution and measurement of **r**adon mass exhalation rate from soil samples collected from all oil exploration areas of Mizoram.

Location	J_M mBq/kg/h	Grain Size Distribution				
		60 (%)	120 (%)	230 (%)	325(%)	>325(%)
Maubuang-1	19.12	71	130.9	36.2	10.5	18.8
Maubuang-2	23.49	17.3	114.2	47	15.2	39.7
Maubuang-3	7.27	73	108.3	41.2	3.5	10.3
Keifang-1	15.62	97.9	118.1	14.5	6.5	17.3
Keifang-2	9.99	67.9	108.6	29.7	15.3	19.1
Keifang-3	11.24	120	166.3	11.4	2.2	1.9
Phulmawi-1	11.76	99	95	43.8	26.9	46.5
Phulmawi-2	7.62	86.9	112.6	36.1	14.8	37.4
Phulmawi-3	16.98	83.6	99.3	34.1	11.6	26.4
Thenzawl-1	19.82	95.5	237.2	113.5	94.1	93.5
Thenzawl-2	9.42	71.3	381.7	46.1	18.6	37
Thenzawl-3	9.89	91.9	314.2	91.2	56.3	87.1
Zanlawn-1	13.89	209.4	265.7	9.4	12.2	36.8
Zanlawn-2	17.88	358.1	223.2	76.5	42.4	45.1
Zanlawn-3	9.13	379.5	207	58.4	87.6	49.6
Meidum-1	17.74	453.8	150.2	16.1	18	22.3
Meidum-2	7.09	364.2	108.3	26.2	5.8	14.5
Meidum-3	7.04	557.1	227.4	60.7	20	36.2

Table 1 gives the results of measurement of radon mass exhalation rates and grain size distribution in soil samples collected from 18 different locations within the study area. All the soil samples were found to be distributed mainly among medium, fine and very fine sand. Radon exhalation was found to be mainly higher in samples having uniform grain size distribution. The measured values of radon mass exhalation rate in Maubuang, Keifang and Phulmawi area of Aizawl district ranged from 7.27 mBq/kg/hr to 23.49 mBq/kg/hr, with an average value of 12.43 mBq/kg/hr. In Meidum and Zanlawn area of Kolasib district, the radon mass exhalation rate ranged from 7.04 mBq/kg/hr to 17.88 mBq/kg/hr, with an average value of 12.13 mBq/kg/hr. And in Thenzawl oil exploration area of Serchhip district the radon mass exhalation rate ranges from 9.42 mBq/kg/hr to 19.82 mBq/kg/hr, with an average value of 13.04 mBq/kg/hr. In the present study of the six oil exploration areas in Mizoram, the radon mass exhalation rate ranges from 7.04 mBq/kg/hr to 23.49 mBq/kg/hr, with an average value of 12.40 mBq/kg/hr.

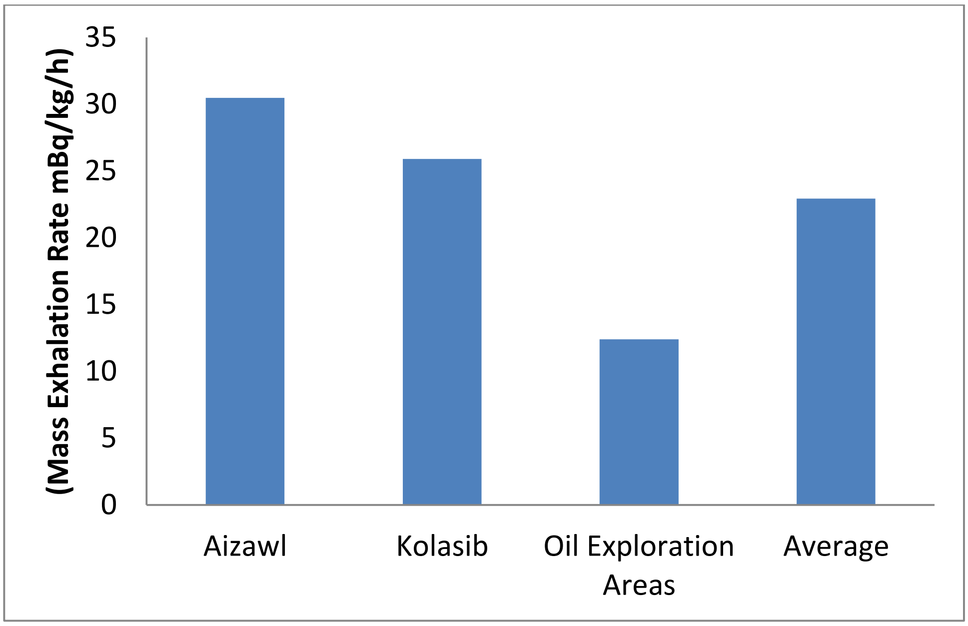


Figure 3: Comparison of the average values of radon mass exhalation rate in Aizawl District, Kolasib District and Oil exploration areas in Mizoram along with the overall average radon mass exhalation rate.

Figure 3 shows the comparison with the average values of radon mass exhalation rate in soils collected from different parts of non oil exploration areas. The soil samples were collected from different parts of Aizawl district and Kolasib district. It had been found that the radon mass exhalation rate in Oil exploration areas is lower than that in Aizawl District and Kolasib District.

5. CONCLUSION

This study presents measurement of radon mass exhalation rates from soil samples collected from oil exploration areas of Mizoram using the Smart RnDuo radon detector. The measured exhalation rates remain almost same in all the location. At the same time as compared to the non oil exploration areas the average value is comparatively low. The results also indicate that radon exhalation tends to be higher in samples with more uniform grain size distribution. The data generated in this work provide valuable baseline information on environmental radioactivity in Mizoram and may support future radiation monitoring, environmental assessment, and public health studies in the region.

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